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ABSTRACT

This paper reports on the processes and results of a project on the instruction and practices of mathematics problem solving and strategies. Students in the second, third, and fifth grades were targeted to increase achievement in the area of math problem solving. Problem solving achievement was measured using performance tasks, rubrics, and tests from September 2001 to January 2002. Appendices include a teacher survey, pretests and posttests, scoring rubrics, problem solving steps and strategies, and writing stems. (Contains 26 references.) (KHR)

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IMPROVING STUDENT ACHIEVEMENT THROUGH INCLUSION OF PROBLEM SOLVING IN THE MATH CURRICULUM

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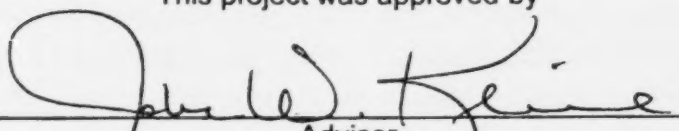

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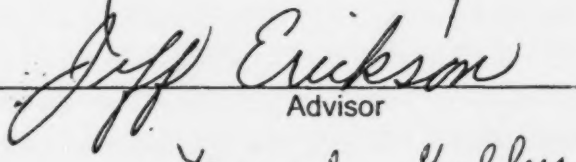

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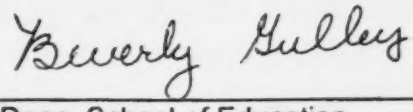

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CHAPTER 1

PROBLEM STATEMENT AND CONTEXT

General Statement of the Problem

In the past, elementary students had difficulty thinking through ways to solve problems in the math curriculum. Targeted students in the second, third, and fifth grade self-contained classrooms had exhibited low achievement in the area of mathematical problem solving. Both state and local achievement tests along with daily work, surveys, informal discussions, and teacher observations have shown evidence that this problem exists.

Immediate Problem Context

Research was conducted at two sites in two different communities. Classrooms A and B were located at Building A while Classroom C was located at Building B.

Site A

Building Description

Site A, built in 1928, is the oldest school building in the district. The school is a two-story, brick building that houses kindergarten through sixth-grade students. The large gymnasium, which is located in the center of the school, contains a stage and is used for many school events and performances. The main floor contains 11 classrooms, the office, a teacher lounge and workroom, and a computer lab. Of the 11 classrooms, 2 are

special resource rooms. One of the resource rooms is for the primary instructional program, which includes kindergarten through third-grade students. The other is for the intermediate instructional program, which includes third through sixth-grade students. The remaining classrooms on this floor are one self-contained kindergarten, three first-grade rooms, three second-grade rooms, and two third-grade rooms. The computer lab, also on the first floor, contains 26 networked computers, printers, and scanner. The main office includes secretary desks, a room for ill students, and the principal's office. Attached to the main office by an internal door is the teacher lounge and workroom. Included in the workroom are teachers' mailboxes, a laminator, two copiers, and a dye-cut machine. There is also a bathroom, many kitchen amenities, and six round tables with chairs. Teachers may also use the computer and printer which has Internet access. The main floor has two bathrooms located off of the gymnasium and two bathrooms along the first and second grade hallways.

The second floor is made up of 10 classrooms, a teacher bathroom, student bathrooms, a speech and language classroom, a resource room for students in kindergarten through sixth grade, and a large balcony overlooking the gym. One classroom on this floor is for third grade. Of the remaining seven classrooms, there are two rooms for fourth, fifth, and sixth grades respectively, along with a room for Title I math.

Housed in the basement of this large school are other miscellaneous rooms. These include a music room, library, gifted-program classroom for students in fourth through sixth, and a reading-recovery classroom, which provides reading instruction for students in kindergarten through third grade.

Classroom Description

Classroom A at Building A was a second-grade classroom located on the main floor. It was very warm and inviting for students. The walls were covered with entertaining and educational posters. Along the west wall was an entire bulletin board, which contained the calendar, helper chart, star of the week area, author of the week area, and monthly behavior incentives. Along the east wall were windows with built-in bookshelves containing books for student reading. Located on the south wall was the student closet area. The teacher area was in the southeast corner of the room. Included in this area were the angled teacher's desk with filing cabinets on each side. Behind the teacher's desk were built-in bookshelves used to house teacher resources, supplies, and materials. On the north wall were the chalkboard and two computers for student use.

The classroom was comprised of 23 flattop desks arranged in groups of 4 or 5. A large carpeted area was available for small or whole-group instruction and storytime. There were many book characters that were kept on the carpet area for students to enjoy while reading. There was a large easel, teacher chair, and a slanted book holder on the carpeted area.

Classroom B was a fifth-grade classroom located on the second floor of Building A. The classroom was organized with 25 flattop desks arranged in groups of 9 or 7. Located in the back corner diagonally opposite the door was the teacher's work area. The work area included a large desk and an Internet-accessed computer. Running along the front of the classroom was a blackboard. This was the area of the room where the majority of the teacher's instruction took place. Across from the blackboard was an outside wall with many large windows and a lower bookshelf. The classroom included a carpeted reading corner that had pillows and beanbags available for student use. Two

computers that were networked to the district server were provided for the students. The room was brightly decorated and student work was often on display. Music, which was appropriate to the situation, could often be heard.

Student Demographics

Building A had a total enrollment of 355 students. Of this number the racial or ethnic background was as follows: 98% White, 0.6% Black, and 1.4% Hispanic. The student population was also comprised of 14.9% low-income students. To be considered low-income, students may come from families receiving public aid, foster homes supported with public funds, or families eligible for free or reduced-price lunches.

Other possible factors affecting achievement include attendance, truancy, and mobility rate. Building A had 64% of students living with two parents, 10% of students living with a parent and stepparent, 26% of students living with one parent, and fewer than 1% of students living with grandparents. Attendance at Building A was 95.5% with truancy at 0.0%. The mobility rate is based on the number of students who enroll in or leave a school during the school year and are counted each time they enter or leave the district. The mobility rate at this site was 15.1% (School Report Card, 2000).

Staff Demographics

Building A had a total of 16 classroom teachers. In addition, there were two special education teachers, one for students in kindergarten through third grade and one for students in fourth through sixth grade. The primary special education teacher had one full-time classroom aide, and the upper elementary special education teacher had one full-time and one half-time classroom aide. This site also had one physical education teacher and one music teacher. The librarian and gifted program instructor were on site only half-time. The Title I math program had one full-time and one half-time teacher.

Building A had one full-time secretary and two part-time clerical aides. There was one principal at this building. The average classroom size was 18.7 students.

The teaching staff at this site was 100% White with an average of 16.5 years of experience. There were 52.8% of teachers who had bachelor's degrees while 47.2% of teachers had master's degrees or above (School Report Card, 2000).

Programs Offered

Building A offered several programs for students, ranging from the fine arts to various extracurricular activities along with the regular grade level curriculum. Curriculum offered in the second grade classroom consisted of math, reading, spelling, English, handwriting, science, and social studies. All of these subjects, except for handwriting, were also included in the fifth grade classroom. For students in sixth grade, the Drug Abuse Resistance Education Program (D.A.R.E.) was offered. Chorus, band, and orchestra programs were also available for those in fifth and sixth grades. A program available to all was Patriots Are Learning Students (PALS). This was an afterschool program that had a variety of activities for the students to choose from. These extracurricular classes met in the spring for six weeks. Teachers volunteered to lead a variety of programs, and students were allowed to join on a first-come, first-served basis.

District

Building A is one of four elementary schools in a unit district of 2,815 students. Besides the elementary schools, the district also consists of a junior high and high school. The high school recently constructed a performing arts auditorium, which is also available for community use. The racial makeup of the district was as follows: 97.1% White, 0.2% Black, 1.1% Hispanic and 1.6% other. The average sized rural district covers an area of approximately 80 square kilometers. Of the 349 faculty and staff

members, 199 are state certified, classroom teachers. One hundred percent of the certified teaching staff was White with an average teaching experience of 16.5 years (School Report Card, 2000).

Community

Building A is located in a Midwestern community of 15,430. The average family income in this community was $45,813 (1996 Special Census). The community, often considered conservative, was experiencing an influx of families who were building and/or purchasing large, up-scale homes in many new subdivisions. More than 80% of these homes are within walking distance from one of the four grade schools located in the district. The neighborhood feeling is very important to the families who call this community home. Another strong identifier of this community is its solid relationships with the churches. Its strong spiritual roots have held this community together since the mid-1800s. There are more than 25 churches and several church organizations that add to the vigorous religious environment. Two private, religion-based schools are available to the families who choose not to attend the public unit district. Also, home schooling was very organized in the community. Many of the home schooling families have a strong religious connection (Local Chamber of Commerce Publication, 2000).

Beautiful homes and parks make up the center of Community A. However, there are many more features just as important to the success of the area. Some of the richest farmland in the country surrounds the community on all four sides. Many rural families use the community's schools, churches, and services. Some of the services that are available are emergency and urgent care facilities, physicians, dentists, and veterinarians. Also, there was a new growth in tourism with six hotels recently constructed. Because of the community's easy accessibility to two major interstates and its proximity to larger

centers of commerce, it can offer the combined resources of larger urban areas with the convenience and lifestyle of a smaller community (Local Chamber of Commerce Publication, 2000).

When thinking of the business sector of Community A, three major industries come to mind. The largest employer of the entire region is a manufacturer of construction and mining equipment that had sales and revenue of $21 billion. A factory for this manufacturer is located in Community A. Next, a major-label food processing plant operates year round. This company is especially busy when their crop is harvested in late summer. The five major trucking firms that are based in Community A have employed over 3,000 people. Once again, the accessibility of the interstates and the proximity to larger urban areas make trucking a major source of revenue for the community (Local Chamber of Commerce, 2000).

Site B

Building Description

Building B, built in 1911 and added onto in 1936, 1950, and 1954, is a kindergarten through fourth grade primary school. The school, located in an upper-middle class section of the city, is housed in two brick buildings each having two levels. The buildings are divided by a busy road, which the students must cross for special classes during the day and to catch the bus after school. Both buildings have a large playground behind them. The east building has four sections of kindergarten and first grade. It also contains three special education classrooms, a science lab, and an office with a copy machine and mailboxes for the teachers. The building to the west has four sections of second, third, and fourth grades. It also has a gym, an all-purpose room,

computer lab, a library, three special education classrooms, and an office for the principal with a teacher workroom attached. Each of the buildings has its own supply room.

Classroom Description

Classroom C was located upstairs in the west building with three other fourth grade classrooms and restrooms for boys and girls. The classroom was comprised of 20 flat-topped desks arranged in cooperative groups of 2 or 4. A carpeted area with a library was along the west wall. A media center with computers and printers was found in the northwest corner of the room. The teacher's desk and file cabinets were in the southeast corner. A large science lab table was located in the front of the classroom. Each student had his or her own mailbox. Half of the west wall was covered with cabinets. Student work hung from the two wires that ran the length of the classroom. Four large bulletin boards, a twelve-foot chalkboard on the north wall, and a twelve-foot white board on the south wall encompassed the surrounding walls. The room was print rich with posters covering more than 50% of the wall space.

Student Demographics

Building B had an enrollment of 413 students. Of the total population, 76% of the population was White, 16% Black, 6.1% Asian/Pacific Islanders, and 1.7% Hispanic. Twenty-one percent of the students were from low-income families. The average class size was twenty students with a 23% percent mobility rate. Each year, 20% to 30 % of the fourth graders move on to the gifted middle school (School Report Card, 1999).

Staff Demographics

The staff was made up of 22 certified classroom teachers and six special education teachers. Of the staff, 92% were female and 8% were male. The staff was 96% White and 4% Black. There were 18 members of the support staff including four special

education aides. The teaching staff averaged 16 years of experience with ten staff members holding a master's degree or above. Each of the two buildings had its own secretary with one shared principal (School Report Card, 1999).

Programs Offered

The curriculum taught in the fourth grade classroom included the subjects of math, reading, spelling, English, social studies, and science. Special programs were offered in orchestra, drama, DARE, and gifted education. Orchestra and drama were available for fourth grade students only. Certified staff members taught physical education, music, and computers. The parent-teacher organization offered these special programs for the students: Run with Reading, Picture Person, Guest Reader, and an art fair. The parents and teachers have worked together to build a strong school.

District

The school is one of 13 elementary schools in a large metropolitan unit district. Twelve middle schools, one gifted middle school, an alternative middle school, one kindergarten through eighth grade magnet school for the fine arts, a trainable mentally handicapped (TMH) primary school, an early childhood center, four high schools, and an alternative high school made up this large unit district. The district also had an adult education center and a diagnostic learning center that housed the early childhood Project Screen. The district had recently handed over administrative duties of two of its elementary and one of its middle schools to a privately-owned educational company. The teacher resource center was housed in one of the middle schools. There were a superintendent, four assistant superintendents, a controller and three directors in the administrative offices, located next to one the middle schools.

The district had an enrollment of 15,134 students made up of 55% Black, 41% White, 2.2% Hispanic, and 1.8% Asian-Pacific Islanders. Sixty percent of the students came from low-income families. The mobility rate for the district was 36%. The faculty was 92% White and 7% Black with an average teaching experience of fifteen years. Of 1,115 teachers, 53% percent held a bachelor's degree while 47% held a master's degree or above. The student to teacher ratio was 19:1 at the elementary level.

Community

The community is located in an agricultural and industrial part of a Midwestern state. Located along a major river with a regional airport, the city has access to major highways and interstates. The city has a council form of government. The community population was 113,504 with 76% White and 21% Black. The median family income was $26,074. The city was primarily made up of single family homes with many apartment complexes. The average cost of a single family home was $83,600. Two large housing projects with many areas of subsidized housing were found throughout the city. Of the 28,454 families, 4,284 were below poverty level. A large area west of the downtown was under urban development. The city has a diverse make-up and was represented by many religious and ethnic backgrounds. Many private and religious schools add to the make up of the educational system of the city. A private four-year university, a two-year community college, and a medical school were available for higher education (http://factfinder.census.gov).

The arts are well represented in the city with a ballet company, symphony orchestra, opera company, municipal band, several theater groups, and a museum of arts and science. In the downtown area of the city is a civic center with an arena that is the home of the local college basketball team and a semi-pro hockey team. The center also

has a theater that is host to regional and national events. In this community one could also find a planetarium, a zoo, and several large city parks. The parks include golf courses, an indoor ice skating rink, and other sports facilities. Throughout the city are several movie theaters, shopping complexes, and one large mall. The area is also host to two professional sports franchises and a riverboat casino. Citizens get their news from four television stations, a daily newspaper, or any of the many radio stations in the area. The community supports the schools through the adopt-a-school program.

National Context of the Problem

Many students cannot solve challenging mathematical problems. The lack of problem solving strategies greatly concerns educators, researchers, and even students. Oftentimes, students do not have the training to solve complex, real life mathematical problems. The strategies necessary for the solution to complex, real life mathematical problems may not be addressed adequately by text resources.

According to Knuth & Jones (1991), much of mathematical instruction time is devoted to drill and practice on math facts and computation and other low-level math skills. "Students may spend far too much time on drill and practice" (Williams, paragraph 6, 7/26/2001). Teachers often focus on memorization and recall instead of critical thinking skills and reasoning necessary for problem solving. According to the National Assessment of Educational Progress (NAEP), "American students perform adequately on low-level cognitive skills such as computation but in general have trouble with higher level cognitive skills involving understanding and problem solving" (Knuth & Jones, para. 8, 1991).

Feeling the pressure of national and state mandated standards, teachers have difficulty finding time to include instruction of problem solving strategies in the math curriculum. "Teachers often provide strong rationale for not including problem solving activities in school mathematics instruction" (Wilson, Fernandez, & Hadaway, para. 20, 7/31/01). The availability of real life problems is often limited or not found in today's math textbooks. Teachers are forced to locate or create problems that would be interesting and relevant to the current school population.

Researchers agree that the importance of teaching mathematical problem solving remains an issue in today's classrooms. In order for the students of today to be productive in the future, they must have a "...facility with math far beyond the basic skills level. This will be extremely important in areas such as engineering, the physical sciences, law enforcement, medicine, economics, and nearly every aspect of business" (Charles & Lester, p. 4, 1982). The need for students to think mathematically and problem solve has increased dramatically because of the vast quantities of information available through the Internet and other multi-media sources.

When comparing students from the United States with students from other countries, the math results are dismal according to Thomas C. O'Brien (1999). He reports that the First International Study of Achievement in Mathematics published in 1967, found that American 13-year-olds finished next to last among 10 major industrial nations. In the Second International Mathematics Study, conducted during the 1981-82 school year, American eighth-graders ranked 10th of 20 national groups in arithmetic, 12th in algebra, 16th in geometry, and 18th in measurement. In all subtests, America's overall scores were at or below the median for the entire group. In a comparison of 14 national groups of 9-year-olds reported in 1992, American children came in next to last, besting

only Slovenia. In the same research, American 13-year-olds tied with Spain for next-to-last place and bested only Jordan. In the Third International Study, which is considered to be the most comprehensive and rigorous international comparison of education ever undertaken, U.S. students fell below the international average. These study results are evidence that the teaching of basics, such as drill and practice, is not sufficient.

Some leaders of industry, such as Campbell Soups, see the importance of developing students' problem solving abilities. The company shares the belief with schools that students "...will need to know a considerable amount of mathematics to be successful in a company like Campbell Soups" (Willis & Checkley, p. 5, 1996). Other industry leaders agree that mathematical reasoning, critical thinking skills, and computation are necessary for workers to be competitive in the future.

At one point in time, during the Industrial Age, employees were responsible to perform low level or repetitive tasks throughout the work day. Now to survive during this time of technological advancement, "...new employees need to have a firm grounding in math using analytical and problem solving skills" (Drew, p. 34, 1996).

Today's teachers need to include problem solving and the necessary strategies throughout the entire curriculum in order to prepare students for a successful future.

CHAPTER 2

PROBLEM DOCUMENTATION

Problem Evidence

Problem solving! Why do we need to teach problem solving? How can we find the time and the necessary materials? Where do we go to learn how to effectively teach problem solving strategies? Why are students unable to solve simple word problems? The reasons why problem solving is not a priority within the math curriculum are as varied as the questions and concerns of educators.

When deciding on a topic for the action research plan, the research team met to discuss various educational concerns that were evident in all the targeted classrooms. Topics such as vocabulary improvement, classroom management, and study skills were evaluated for possible research. The researchers, however, realized that the lack of problem solving skills and strategies were of greater concern than the other topics discussed. Even though problem solving strategies are used throughout the curriculum, the researchers chose to specifically focus on the lack of problem solving skills in mathematics. After deciding on the topic, the researchers met with building administrators to solicit their opinions on the choice. These informal visits between the principals and the researchers

confirmed that mathematical problem solving was indeed a curriculum area that caused concerns. Administrators from both Sites A and B felt that mathematical problem solving was an area in which students were especially weak. The School Improvement Plan (SIP) at Site A and the School Achievement Plan (SAP) at Site B included problem solving as an area to be addressed. Included in the SIP and SAP were instructional strategies teachers could use to strengthen problem solving skills of their students. Some of the strategies included were implementing problem of the day, daily oral math, math resources such as Exemplars, math manipulatives, and integrating technology. To further document the weakness of problem solving skills and strategies, state standardized achievement tests were evaluated.

On the state standardized achievement test, 47 third graders at Site A and 78 third graders at Site B were given two extended response tasks in mathematics. For Task 1, students were to solve the following: with a given amount of money, students choose two different ice cream treats and determine the total cost and the amount of money left over. Task 2 required the students to solve the following problem: on a 4 x 6 grid, students design a floor plan so that ½ of the tiles are blue, ¼ of the tiles are gray, and ¼ of the tiles are red. The tasks were scored on three dimensions: mathematical knowledge, strategic knowledge, and explanation. Mathematical knowledge included mathematical principles and concepts which result in a correct solution to a problem. Strategic knowledge was the identification of important elements of the problem and the use of models, diagrams, symbols, and/or algorithms to systematically represent and integrate concepts. A written

explanation and rationale, that translated into words the steps of the solution process and provided justification for each step was required. Each of the mathematics dimensions was scored on a scale of zero to four with four being the highest.

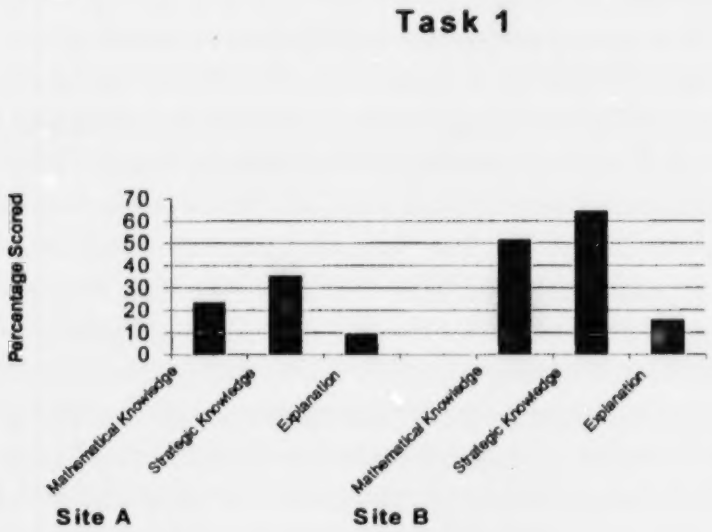

Figure 1. Task 1 was a problem to calculate total cost. State achievement test results for third grade students from Sites A and B are shown.

On Task 1 of the state standardized test as shown in Figure 1 of the 47 third grade students who participated at Site A, 23% (11 students) exceeded the standards set by the state when tested for mathematics knowledge. For strategic knowledge, 35% (16 of the 47 students) exceeded state standards. But when it came to the explanation, or problem solving abilities, only 9% (4 of the 47 students) were able to exceed the state standards.

At Site B, 78 third grade students participated in the state standards achievement test. On Task 1 as shown in Figure 1, 51% (40 of the 78 students) exceeded the standards on the mathematical knowledge portion of the test. For strategic knowledge, 64% (51 of the 78 students) exceeded the state standards. However, when tested for explanation on Task 1, only 15% (12 of the 78 students) exceeded the standards set by the state.

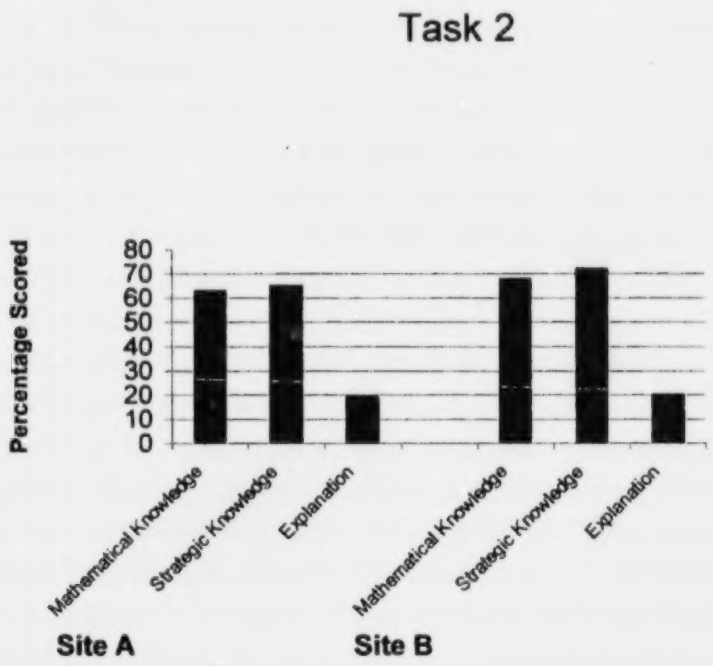

Figure 2. Task 2 was a proportion problem. State achievement test results for third grade students at both Sites A and B are shown.

The test results for Task 2 were similar to those of Task 1 at Sites A and B. The same number of students participated. As shown in Figure 2, at Site A, 63% (31 students) exceeded in mathematical knowledge; 65% (32 students) exceeded in strategic knowledge, while only 19% (9 students) exceeded when tested for explanation or problem solving. At Site B as shown in Figure 2, 68%

(55 of the 78 students) exceeded in mathematical knowledge; 72% (58 students) exceeded in strategic knowledge, while only 20% (16 of the students) exceeded the explanation portion of the task. When examining the standardized tests, both Sites A and B had a low number of students who exceeded on the written explanation, or problem solving, portion of the mathematics test. The state achievement test scores indicated that problem solving skills were indeed a weak area at both Sites A and B.

To collect more information on the status of problem solving at Sites A and B, teachers were asked to complete a survey (Appendix A). The survey asked for feedback on teachers' attitudes and abilities to teach problem solving. At Site A, 14 classroom teachers returned the survey, and Site B had 15 surveys returned.

The survey results for Site A in Table 1 indicated that teachers did not feel comfortable with problem solving. Results that reveal the teachers' discomfort with problem solving were as follows: of those surveyed, 64% said they sometimes or seldom encourage their students to be independent thinkers. As stated by a teacher, "It is difficult to move students toward independent problem solving. It seems to me they are too reliant on a teacher's help; starting with my reading the problem to them." Another teacher stated, "Many teachers are uncomfortable teaching logic and problem solving. I would like more training." Fellow educators felt the same way. Only 7% of teachers felt adequately trained to teach problem solving strategies and steps.

Table 1

Sites A and B Teacher Survey on Problem Solving

Questions	Almost Always	Often	Sometimes	Seldom	Unsure
Do you allow time each day for problem solving instruction?	29%	34%	31%	6%	0%
Do you feel you have adequate training for teaching problem solving strategies and steps?	31%	11%	49%	9%	0%
Is the material used for problem solving current and relevant to real life experiences of students?	20%	29%	40%	11%	0%
How often do you encourage students to be independent thinkers when involved in the problem solving process?	20%	43%	26%	9%	2%
Do you students have the skills needed to solve critical thinking and problem solving tasks independently?	2%	15%	47%	34%	2%

Site B survey results indicated similar attitudes toward mathematics problem solving as at Site A. Teachers felt math curriculum material available for teaching problem solving was not relevant to a student's life. As commented on a survey, one teacher stated, "Teachers need to use real life situations to teach

problem solving. I research problem solving on the Internet to find real life situations applicable to my students' daily lives."

When it comes to skills students need to solve critical thinking and problem solving tasks independently, 54% of the teachers believed that students seldom had these needed skills. "Problem solving strategies have to be developed and taught to students. If it is a continuing process beginning in the early grades, then by third and fourth grades, it becomes a natural way of thinking," shared one participating teacher.

As further evidence of mathematical problem solving weakness, a pretest from the Exemplars program was administered. Exemplars is a standards based performance assessment program that uses performance tasks that reflect the national and state standards in mathematics. Faculties can assess where their students are and how they might be helped using the information gained from working with Exemplars (de Groot, 1997).

Two Exemplars tasks were given: one to the 17 second grade students and a different one to both the 19 fourth and 22 fifth grade students (Appendixes B and C). The results of the pretests were scored using a rubric specifically developed for this plan (Appendix D). The rubric includes a four point scale with four being high, measuring five criteria: Did the student show evidence the problem was understood? Was information used appropriately? Were appropriate procedures applied? Were representations such as graphs, charts, or pictures used, and was competent use of math shown?

The results of the pretest indicated that students were unable to give an extended response to the tasks given. Of the 17 second grade students, five who were given the pretest scored 10 or above on the scoring rubric. When examining the fourth and fifth grade pretests, scores were much lower. From a total of 41 students, none scored higher than 5. Five is the lowest score possible.

At Site A, the second grade class rubric average on the pretest was a eight, while the fifth grade average was five. At Site B, the fifth grade class rubric average was also a five. These scores indicated a serious weakness students had in the area of mathematical problem solving. Students lacked not only the necessary strategies, but also the necessary skills needed for becoming effective problem solvers.

Probable Causes

The lack of student success in problem solving is not new. Many educators have been concerned about their students' inabilities to solve mathematical problems. The literature suggests several underlying causes for the low performance of problem solving in students today. Herrera and Roempler stated "Problem solving should be the central focus of the mathematics curriculum" (para. 5, 7/31/01). Unfortunately that is not the case in many classrooms today. Teachers often complain about the time problem solving takes during daily instruction.

On the survey given at the beginning of the study, teachers indicated that they sometimes do not allow for daily problem solving instruction. Not teaching problem solving on a daily basis is a cause for concern. "We recognize problem

solving skills are necessary, yet we give them inadequate attention in most mathematics classrooms" (Weidemann, para. 1, 7/31/01). Many factors influence a teacher's decision to teach problem solving during their math instruction. "The bottom line is this: there is a limited amount of school time, and yet there are seemingly endless demands on it. And in math classrooms, pressure today is on learning facts, honing skills, and memorizing definitions" (Herrera & Roempler, para. 5, 7/31/01). Most teachers feel they have too many other skills to teach during math instruction as shown in Table 1. District curriculum and textbooks typically focus on computation and other lower level skills. This type of instruction also takes time. State mandated tests and achievement tests "...lead[s] to pressure to cover lots of material and teachers feel pressure to forego problem solving" (Wilson, para.2, 1993). Regardless of the amount of time teachers feel they have for teaching problem solving, they need to make a commitment to making problem solving a significant part of the math curriculum.

Inadequate attention given to problem solving is also due to the fact that teachers lack training. Teachers may not have taken a refresher course to update themselves on the importance of problem solving in today's classrooms or to learn the strategies and skills they need to teach their students. Teachers do not receive "...ongoing and intensive professional development that allows teachers to interact with their colleagues" (North Central Regional Educational Laboratory [NCREL], para. 11, 9/05/01). Districts may fail to provide teachers with in-services that address this issue. The survey results indicated that teachers felt they do not have adequate training for teaching problem solving strategies and skills.

This lack of preparation causes educators to feel insecure about teaching problem solving strategies and skills.

In problem solving it is necessary to teach strategies and skills because "Students are largely unaware of the processes involved in problem solving" (Wilson, para. 15, 1993). Students are so used to finding a quick solution that they do not use the appropriate strategies when confronted with a problem solving task. However, often times they do not have the necessary strategies and steps to be good problem solvers. "According to the National Assessment of Educational Progress (NAEP), American students perform adequately on low-level cognitive skills such as computation but in general have trouble with higher level cognitive skills involving understanding and problem solving" (Knuth & Jones, para. 9, 9/05/01). Educators need to teach problem solving strategies and steps. They need to give students the background information for solving extended response tasks which in turn will allow them to think about the processes involved in problem solving.

McAllister stated "Sometimes students resist problem solving because they know if they wait long enough, we will give them the answers" (para. 11, 9/05/01).

> Despite the importance of math and the potential enjoyment that students can experience from it, it is a fact that the majority of students grow to dislike math (or become indifferent to it) by the time they complete elementary school. We attribute this state of affairs to the overemphasis on drill and practice, to the general

absence of attempts to involve students in real-world applications of math, and to the lack of attempts by teachers and textbooks to engage students in real explorations and problem solving activities (Charles & Lester, p. 4, 1982).

CHAPTER 3

THE SOLUTION STRATEGY

Literature Review

"Problem solving is the cornerstone of school mathematics" as stated in the National Council of Teachers of Mathematics (NCTM) Principles and Standards for School Mathematics. Considering the importance of problem solving, it is puzzling that it has been taught as a separate component and frequently even overlooked as an integral part of the math curriculum. When problem solving is taught, students learn isolated steps and strategies that are typically difficult to connect to prior knowledge. Teaching problem solving strategies, while making the process and problems meaningful to students, is critical to student success as problem solvers. It is now understood that "...success in problem solving breeds success in learning" (McAllister, para. 9, 9/05/01).

Preparing our students for the future needs to be a common goal of every classroom teacher. Businesses have stated they need people who are thinkers and problem solvers.

> "By learning problem solving and mathematics, students should acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics

classroom. In everyday life and in the workplace, being a good problem solver can lead to great advantages" (NCTM, pg. 52, 2000). Teachers who teach problem solving encourage students to figure things out on their own and stay with a task even when difficult (NCTM, 2000).

The deficiency of problem solving skills and strategies as related to students is often the focus of concern. However, many teachers do not feel comfortable or have the knowledge to teach mathematical problem solving. According to Burns (2000), it is important for the teacher "...to convey, through actions and words, that mathematics is essential in today's world." Teacher preparation to teach problem solving can have an impact on student achievement. "It's not fair to expect teachers to teach what they don't understand themselves" (Burns, pg. 23, 1992). According to NCTM, taking courses and attending workshops, conferences, and other professional development activities, along with self reflection, are all ways that teachers can increase their knowledge of mathematics (NCTM, 2000). Marilyn Burns suggested that teachers need opportunities to revisit school mathematics topics in ways that will allow them to develop deeper understanding of the subtle ideas and relationships that are involved between and among concepts (1992). Even when unsure and uncomfortable, teachers need to model positive attitudes about problem solving in order to help students develop the same. When teachers genuinely do not know an answer, their modeling of good questioning and learning behaviors gives students a clear message about math processing and the value of thinking.

Effective teaching requires a positive classroom environment conducive to problem solving. Teachers need to encourage students to share successes and failures

and to explore a variety of solutions. Organizing classrooms so that students think and talk about their work, share ideas, and question other students can contribute to problem solving success (California Department of Education, 1992). Discussion has a key role in learning about mathematical thinking. When students can explain and share, they increase their knowledge of the concept. Children learn to face the fact that not everyone has the same perspective as they do. "Teachers should provide many opportunities for children to interact with each other informally" (Andrews, p. 22, 1996). Besides providing support between students, NCTM Standards (1995) state that these cooperative learning opportunities enable teachers to interact more closely with students and provide more time for students to develop their ability to communicate and reason. In this type of environment, students are more willing to take risks in problem solving. Teacher attitudes and actions interact to form the classroom climate. "Cooperative learning approaches are appropriate for mathematics students at all levels and for the preparation of mathematics teachers" (Wilson, p. 7, 7/31/01).

Students in today's classrooms find mathematical problem solving difficult. Many times students do not know where to begin in order to tackle the complex thinking involved in problem solving. Students, not wanting to admit their lack of knowledge and feeling they should already know how to solve these problems, lose confidence in their ability to problem solve. They quickly become frustrated and give up. Weidemann stated one student's frustration as "I always sat by myself at my desk and worked on my own when trying to solve 'word' problems. I always became discouraged very quickly and gave up on the problem" (p. 3, 2001). This may reflect the attitude of a student who feels isolated and untrained in problem solving. The difficulty students have limits their

effectiveness of using problem solving as a tool in exploring, using, and understanding concepts in other subject matter.

Unfortunately, many students' problem solving backgrounds are deficient. When students lack the necessary steps and strategies, it is difficult to become successful problem solvers. "The student just does not know what steps to take when confronted with a problem" (McAllister, para. 9, 9/05/01). Teachers must develop a framework for students to think about the processes involved in mathematical problem solving. George Polya, a famous mathematician in his book How to Solve It, describes four steps that can make problem solving easier. Polya's four problem solving steps, as cited and explained in Painless Math Word Problems (Abramson, p. 3, 2001), are: understand the problem, plan a strategy, do the plan, and check your work. In order for students to understand the problem, they need to read the problem carefully to be clear about the question that is being asked. Planning a strategy involves deciding what to do such as adding, subtracting, drawing a picture, or making a list. Doing the plan means carrying out the strategy. Checking your work means rereading and redoing the problem to make sure the work is mathematically accurate and that the answer makes sense. These steps need to be given instructional attention if the students are expected to use them.

Following the instruction of the problem solving steps, teachers need to incorporate specific strategies for problem solving. "Different strategies are necessary as students experience a wider variety of problems" (NCTM, p. 54, 2000). These strategies, introduced one at a time, will give students the background necessary for solving many types of problems. Guess and check, draw a picture, choose an operation, make a chart or table, find a pattern, and work backwards are the most often used strategies in

elementary math (Charles & Lester, 1982). One strategy used to solve problems is guess and check in which one guesses at a possible answer and then checks to see if the guess is reasonable and works. Looking for a pattern is organizing data and finding repetition of that data. Working backwards is when the answer is given and the information must be determined as to how the answer was achieved. Making a chart or table allows students to analyze data that is provided in the problem. Choose an operation instructs students on locating key words or phrases in the problem so they can select whether to use addition, subtraction, multiplication, or division to solve the problem. Drawing a picture gives a visual representation so that students can see the problem in action. Even though these strategies are taught individually, "...rarely does one single strategy suffice to solve a problem. Rather, it is usually a combination of strategies that is required (Krulik & Rudnick, p. 29, 1989). Therefore, problem solving success is not immediate but happens over time as more strategies are learned.

When students are asked to problem solve, they are often given isolated problems from a specific page of text. These problems have little or no meaning to the students' real world. "Teachers across North America are striving to make math relevant to students' daily lives, not just something found between the covers of a textbook" (Willis & Checkley, p. 1, 1996).

> Making traditional word problems the only or main emphasis of the problems children encounter is not sufficient for the elementary curriculum. Doing so gives an unrealistic message to children about the way mathematics will serve them as adults. Most daily problems adults face that require mathematics reasoning and skills are not solved by translating the available information into

arithmetic sentences and then performing the needed calculations (Burns, p. 15, 1992).

When faced with actual life situations, such as purchasing or ordering materials, students have few strategies to assist them with these tasks. "It is not enough for students to produce answers to preorganized exercises; they must be able as well to use mathematics to help make sense of real situations" (California Department of Education, p. 16, 1992). Teachers have failed to provide real world problems. As an example, a teacher in an urban setting would not want to use the following: Patty and Jerry live on a farm. In their barnyard they have chickens and pigs. There are 58 legs total. How many of each animal is on the farm? Students who do not live near a farm would have no desire to solve the problem or previous experience with the information. In contrast, a problem such as: The total cost of a movie ticket and popcorn is $11. The tickets cost $5 more than the popcorn. Find the cost of the movie ticket. This problem is more likely to be relevant and have a relationship to real life. Students learn and retain material when it is relevant to them. They need to realize that problem solving is used in reading graphs, telling time, deciding on the best products to buy, and balancing a checkbook. Extended response tasks on state achievement tests are beginning to reflect more real life situations. However, when students are asked to explain answers and provide justification on the steps used, the majority are still unable to do so. According to Mathematics for the Middle Grades (NCTM, 1982), one source of real world problems is the daily newspaper. The 7newspaper can provide a variety of exercises and activities focusing on such topics as averages, ratios, large numbers, and percentages. Another source of real life word problems would be the Internet. "The Internet is a river of resources for practicing and

solving all kinds of real life word problems" (Abramson, p. 275, 2001). "Teachers need worthwhile activities: problem scenarios dealing with substantive subjects matter, embedded in a context understood by the student, and sufficiently challenging to hold student interest and demand critical thinking" (Herrera & Roemplar, p. 2, 7/31/02). Finding routine applications of mathematics in everyday settings is clearly possible.

One of the important aspects of problem solving is taking the time to reflect or looking back to evaluate if there was a better way to solve the problem. This step is often overlooked. Therefore, success in solving problems has been impacted. "Reflection is a powerful and underutilized tool in problem solving instruction" (Middleton, para. 39, 7/31/01). The NCTM states that students should be encouraged to reflect on complex problems (2000). Without reflection, students cannot fully develop the thought process that is needed and useful in solving future problems. According to Posamentier, Hartman, & Kaiser, "Teachers should make sure students understand why, when, and where to apply mathematical procedures, concepts, algorithms, and strategies" (p. 3, 1998). Having students keep journals is one way they can reflect on their learning. Posamentier, Hartman, & Kaiser continue that "Journals should include descriptive and evaluative information" (p. 3, 1998). Writing is often overlooked in the math curriculum. When students are given time to reflect in their math journals, they can express their frustration and confusion without embarrassment. They can also be asked to respond to specific questions about a math lesson or problem. "Teachers should ask students to reflect on, explain, and justify their answers so that problem solving both leads to and confirms students' understanding of mathematical concepts" (NCTM, p. 121, 2000).

Project Objectives and Processes

As a result of instruction and practice of math problem solving processes and strategies, the targeted second, fourth, and fifth grade students will increase achievement in the area of math problem solving. The intervention will begin in September 2001, and end in January 2002. Problem solving achievement will be measured using weekly performance tasks, rubrics, and tests.

In order to accomplish the researchers' objective, the following procedures will be utilized:

1. Select problem solving strategies for instruction (Appendix E).
2. Choose and copy activity tasks for each grade.
3. Create writing stems for weekly math journal (Appendix F).
4. Create scoring rubric that will be used on pretest, posttest, and weekly activity tasks.
5. Create and distribute teacher problem solving surveys
6. Pretest will be administered to the second, fourth, and fifth grade students who are participating in the group's intervention.
7. Allow time for weekly student reflection in math journals.
8. Teachers will use checklist to record strategies written about by students in the math journals.
9. Activity tasks will be completed using cooperative learning groups at each teacher's discretion.
10. Weekly classroom instruction of problem solving strategies may be practiced using activity tasks or computers.
11. Posttest will be administered to all students who have participated in the intervention.

Action Plan

The following action plan is intended to improve math problem solving achievement by using a specific instructional plan along with allowing students ample time and realistic problems throughout the intervention.

WEEK # 1

- Teacher will administer pretest to each student.
- Teacher will score pretest using a rubric.
- Teacher will distribute and collect problem solving survey

WEEK # 2

- Teacher will use an overhead and provide each student with rubric used to score pretest and other problem solving tasks.
- Teacher will put examples of completed problems on overhead, and students will score as a class.
- Teacher will explain expectations for student math journal (how to use, when it will be used, and why it is valuable to write about their problem solving).
- Teacher will refer to posters displayed in classroom. These posters will include the steps used in problem solving, the strategies used in problem solving, and the stems used for math journal reflections.
- Teacher will instruct students on the steps used in math problem solving (Appendix G).
- Teacher will begin instructing students on the first problem solving strategy: choose an operation.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 3

- Teacher will continue instruction on the first problem solving strategy: choose an operation.
- Teacher will remind students about referring to problem solving posters throughout the classroom.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 4

- Teacher will continue instructing students on the first problem solving strategy: choose an operation.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 5

- Teacher will begin instructing students on the second problem solving strategy: draw a picture.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 6

- Teacher will continue instructing students on the second problem solving strategy: draw a picture.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 7

- Teacher will begin instructing students on the third problem solving strategy: make a chart or table.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 8

- Teacher will continue instructing students on the third problem solving strategy: make a chart or table.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK # 9

- Teacher will begin instructing students on the fourth problem solving strategy: find a pattern.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #10

- Teacher will continue instructing students on the fourth problem solving strategy: find a pattern.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #11

- Teacher will begin instructing students on the fifth problem solving strategy: work backwards.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #12

- Teacher will continue instructing students on the fifth problem solving strategy: work backwards.
- Each student will complete an independent problem solving task.

- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #13

- Teacher will begin instructing students on the sixth problem solving strategy: guess and check.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #14

- Teacher will continue instructing students on the sixth problem solving strategy: guess and check.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #15

- Teacher will monitor student progress during a review of the six problem solving strategies.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #16

- Teacher will continue monitoring student progress during a review of the six problem solving strategies.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #17

- Teacher will continue monitoring student progress during a review of the six problem solving strategies.
- Each student will complete an independent problem solving task.
- Teacher will score each student's task using the rubric.
- Students will be allowed time to reflect on this week's problem solving in their math journal.
- Teacher will review student math journals and complete teacher checklist.

WEEK #18

- Teacher will administer a posttest to each student (Appendixes H and I).
- Teacher will score each student's posttest using the rubric.

Methods of Assessment

Throughout the intervention, students completed a pretest, kept a math journal, and completed a posttest. Students were given a weekly performance task to complete. These assessments were scored using a rubric that the researchers developed. The researchers administered all assessments during the intervention. The teacher-developed rubric was used and kept to measure growth and improvement.

CHAPTER 4

PROJECT RESULTS

Historical Description of the Intervention

The objective of this project was to increase student achievement in the area of math problem solving. In order to accomplish this objective, the researchers reviewed standardized test scores, interviewed school administrators for educational concerns as related to problem solving, and surveyed teachers on their attitudes of math problem solving. The researchers also found that mathematical problem solving was addressed in each school's improvement plan. These factors led the researchers to conclude that math problem solving was an area of concern.

As part of the plan, researchers administered a math pretest from the Exemplars' program that required an extended response similar to questions found on state standardized tests. The pretests were scored using a rubric for problem solving. After the pretest, students were instructed on the steps needed in problem solving. These four steps included: think about it, choose a plan, carry out your plan, and check your answer. Bi-weekly instruction of the six selected problem solving strategies was then initiated. The selected strategies were: guess and check, make a table, find a pattern, draw a picture, work backwards, and choose an operation. In addition to instruction, students

were given time for practice and weekly reflection in their math journals. Original plans for the math journals were for the students to choose one of four specific questions for reflection. These questions were to write about which strategy was used during the week, what was learned during the week, what could have been used, and what was not understood about the strategies. After two weeks, the questions were changed to Mrs. Potter's questions. These questions were: What were you expected to do? What did you do well? What would you do differently? What help do you need from me? Each week, students were given an Exemplars' task that teachers scored using the same rubric for problem solving. At the end of the 18-week intervention, students were given an Exemplars' task as a posttest to measure improved scores on extended response tasks. The posttest was also scored with the rubric.

Presentation and Analysis of Results

Researchers administered pretests at Sites A and B. Pretests were scored and recorded using a problem solving rubric. This rubric assessed such skills as showing evidence that the problem was understood, using information appropriately, applying appropriate procedures, using representations, charts, graphs, and showing competent use of math. At Site A in Classroom A, the second-grade students' scores ranged from 5 to 15 on a possible 20 point scale. The average score was 8. In Classroom B at Site A and Classroom C at Site B, the fifth and fourth-grade students scored an average of five points using the same rubric. No students earned more than the lowest score possible in these two grades.

In order to assess the effects of instruction of problem solving steps and strategies, a weekly task was administered and scored using the problem solving rubric. The data

were collected and recorded to show improvement in the use of the current and previously taught problem solving strategies. These data were aggregated weekly and are presented in Figures 3, 4, and 5.

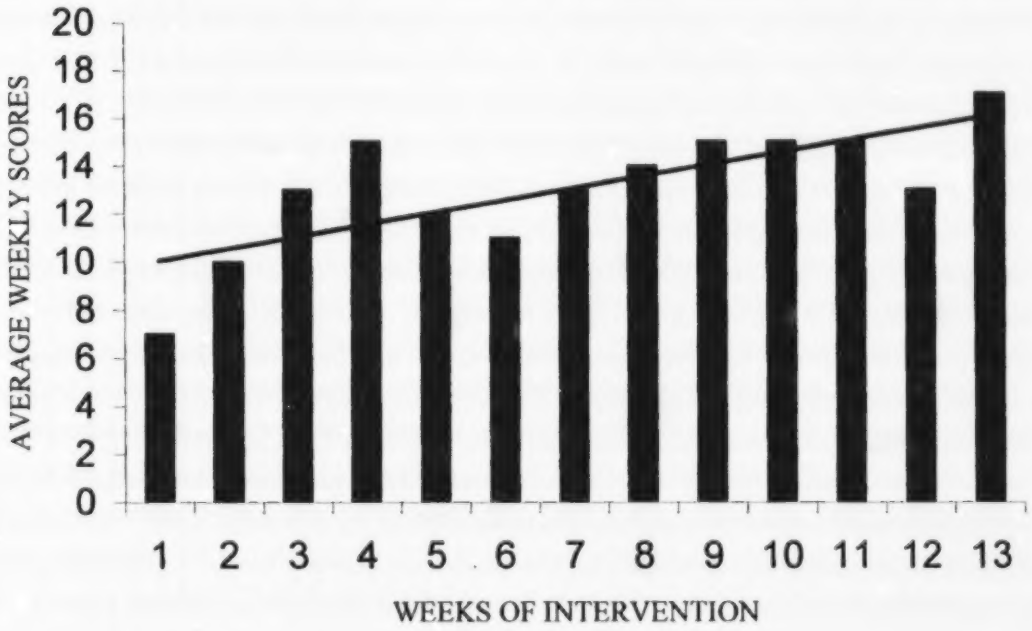

Figure 3. Average scores, with a maximum of 20 points, for weekly extended-response tasks administered in targeted second grade classroom.

The second grade students began the 13 weeks of intervention with limited knowledge on how to complete extended response tasks. The students were first instructed on the four problem solving steps of think, plan, solve, and look back. Then each week students were instructed on a specific strategy in order to solve the weekly extended-response task. During the weeks of intervention, there was a marked improvement. In the second grade classroom, weekly task scores increased 35% from the first week of intervention to the conclusion of the plan as shown in Figure 3. Students' scores improved 10% from week 3 to week 4. A possible reason for the score increase

was because the students viewed the strategy as art instead of math problem solving when additional time was given for students to work on their drawings. From Week 4 to Week 5, there was a 15% decrease in the average weekly score. The possible cause for the decrease during Week 5 was because the extended response task required the students to work backwards, a strategy that had not yet been taught. Weekly extended response scores decreased 10% from Week 11 to Week 12. The possible cause of this decrease was due to the Christmas excitement and activities in the classroom.

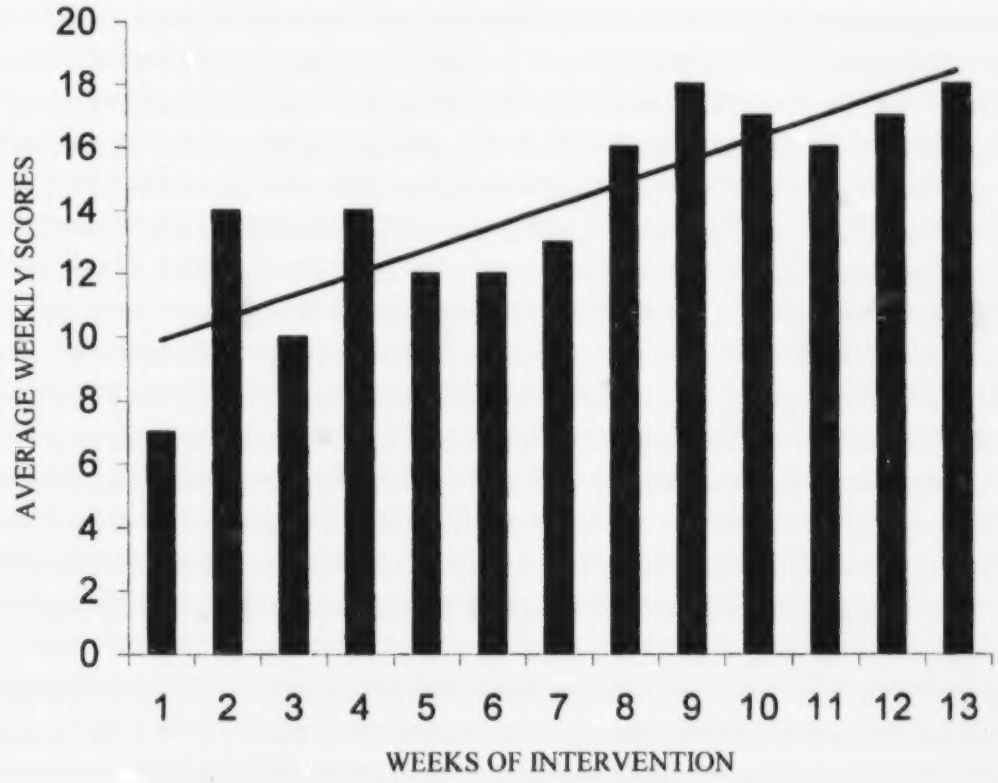

Figure 4. Average scores, with a maximum of 20 points, for weekly extended response tasks administered in targeted fourth grade classroom.

The fourth grade students demonstrated limited knowledge on how to solve extended response tasks prior to intervention. However, once students were taught the

specific steps and strategies that are essential in problem solving, improvement was evident throughout the intervention plan. Students were not only able to solve the task but also able to determine which strategy should be used. During the weeks of intervention, there was a marked improvement. In the fourth grade classroom, weekly task scores increased 55% from the first week of intervention to the conclusion of the plan as shown in Figure 4. An improvement of 35% from week 1 to week 2 was possible because a below grade level task was administered to the students. The researcher felt this deviation was necessary to allow students to overcome their fears of extended response tasks. During week 3 there was a 15% decrease because the students returned to a grade level task which was more challenging to complete.

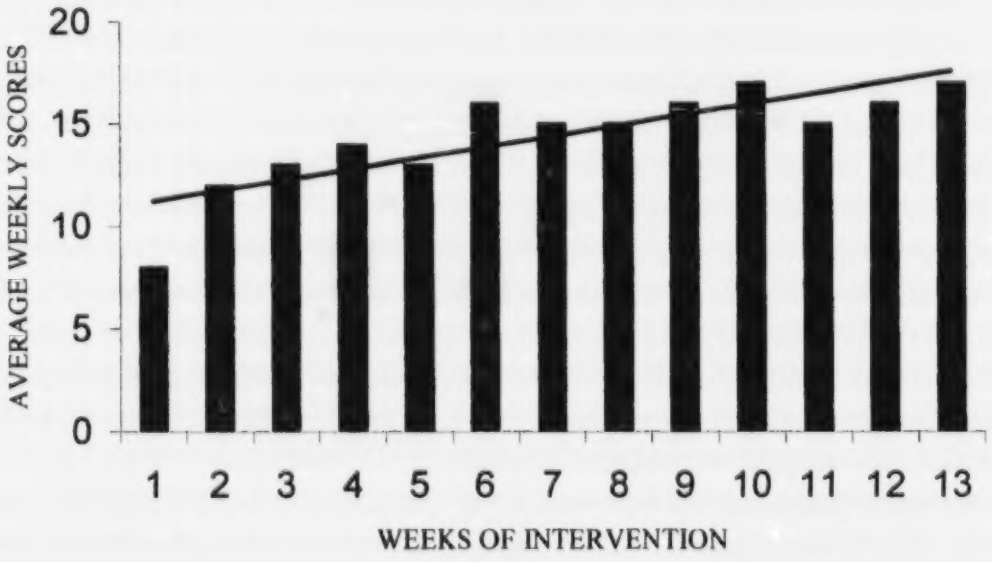

Figure 5. Average scores, with a maximum of 20 points, for weekly extended-response tasks administered in targeted fifth grade classroom.

The targeted fifth grade students demonstrated minimal ability to solve extended response tasks using appropriate steps and strategies at the start of the intervention plan.

With weekly instruction and practice of the six problem solving strategies, the students were then able to select appropriate strategies, solve the extended response tasks, and demonstrate understanding when explaining their solutions. As the intervention continued, student success was evident. During the weeks of intervention, there was a marked improvement. In the fifth grade classroom, weekly extended response task scores increased 50% from the first week of intervention to the conclusion of the plan as shown in Figure 5. From Week 1 to Week 2, students' scores improved 15% on the weekly extended response task. A possible explanation for the increase was because of additional instruction of the steps necessary to solve a problem. By looking at the weekly averages for the targeted classroom, a meaningful improvement in problem solving achievement appeared to be evident.

At the end of the weeks of intervention, an Exemplars' task was used as a posttest in each of the three classrooms. The posttest was scored using the problem solving rubric. When comparing the pretest and the posttest averages, a meaningful improvement was evident, especially in the fourth and fifth grade classrooms. The scores in Classroom A, the targeted second grade students, increased from a pretest average score of 8 to a posttest average score of 15 (35%). Classroom B, the targeted fifth grade students, increased 65% from a pretest average score of five to a posttest average score of 18. The targeted fourth grade students in Classroom C increased 55% from a pretest average score of 5 to a posttest average score of 16. The posttest averages were compared to the pretest averages as seen in Figure 6.

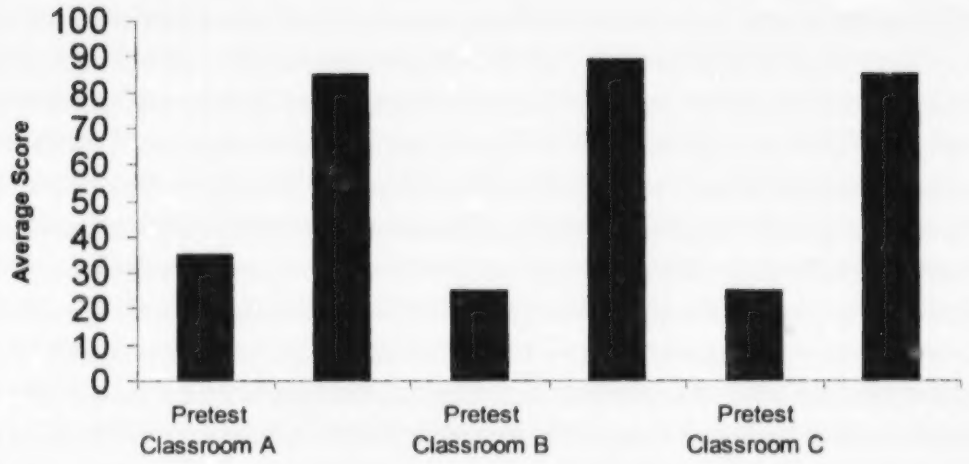

Figure 6. Comparison of pretest and posttest averages, with a maximum of 20 points, in Classrooms A, B, and C.

All targeted second, fourth, and fifth grade students were given an extended response task for both the pretest and posttest. On the pretest, the targeted second grade students in Classroom A demonstrated limited knowledge of how to complete this type of problem solving task. At the completion of the intervention plan, these same second grade students showed evidence of improvement by scoring higher on the posttest with an increase of 50%. The targeted fifth grade students in Classroom B demonstrated minimal knowledge of problem solving strategies when given the intervention pretest. After the 13-week intervention, these same students showed marked improvement as evidenced by the 65% increase on the posttest. The targeted fourth grade students in Classroom C increased their score from 25% on the pretest to 85% on the posttest showing a 60% increase.

Conclusions and Recommendations

Based on the presentation and analysis of the data on mathematical problem solving, the students showed a marked improvement. The problem solving steps and strategies learned during the intervention appeared to have improved student achievement on extended response tasks as evidenced through data comparison in Figures 3, 4, 5, and 6.

The researchers observed the changes in facial expressions and behaviors throughout the intervention. Grimaces and groans were replaced with smiles and enthusiasm when students were asked to problem solve. At the onset of the intervention, many students would sit and listen but have no involvement. As the intervention progressed, students were often asking questions of the researchers and their classmates. These questions showed the students had gained insight and knowledge of the problem solving process. When students were taught specific strategies that they could use for problem solving, the students showed improved confidence as demonstrated in their weekly math journals. One student reflected, "When we first started on Exemplars' problems, I hated them, but now I love them." A fifth grade student commented, "I liked the problem solving because it was very fun. I wish we could do it every day." No longer did the majority of students think of math problem solving with a negative attitude. It was evident to the researchers that many students were becoming independent thinkers and problem solvers. After completing the posttest, students were asked to reflect how they felt at the beginning of the intervention and then how they felt at the end. One fourth grade student summed it up best. She wrote, "I felt like it (problem solving) was hard and confusing, and I was confused and frustrated. Now I feel relaxed and

happy because I understand it, and I am not frustrated anymore because I figured out how to do it." In fact, on review of all student responses to that question, 95% of students had a negative attitude at the beginning of the intervention compared to 14% at the end. Only 8 out of the 59-targeted students still viewed problem solving as a difficult task. A positive attitude was evidenced by 86% of the students when reflecting in their math journals.

In review of the action plan, specific modifications would be advised. One important modification would be to use a student-friendly scoring rubric. The rubric used throughout this action plan included vocabulary too difficult for students to understand. Even upon implementation by the researchers, they found the rubric to be difficult for assessment. A deviation that was implemented during the action plan was the use of Mrs. Potter's questions for journal reflection. It is strongly recommended that these questions replace the original questions for journal reflection. The students were able to be independent in their journal writing when the new questions were used as compared to their confusion and misunderstanding with the original questions. A third modification that would help this plan to be more successful would be to understand that the grade levels written on the extended response tasks were not always appropriate. The fourth and fifth grade students frequently used a K-2 task instead of the expected 3-5 task. However, the 3-5 posttest that was selected prior to the intervention was still used at the conclusion of the plan.

The action plan developed by the researchers may be adjusted to fit any grade level. The researchers agree that with the implementation of the modifications previously

addressed, the action plan to improve student achievement through inclusion of problem solving in the math curriculum supports increased chances for success.

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APPENDIX

Appendix A
Teacher Survey

Problem Solving Survey

	Almost Always	Often	Sometimes	Seldom	Unsure
Do you allow time each day for problem solving instruction?					
Do you feel you have adequate training for teaching problem solving strategies and steps?					
Is the material used for problem solving current and relevant to real life experiences by students?					
How often do you encourage your students to be independent thinkers when involved in the problem solving process?					
Do your students have the skills needed to solve critical thinking and problem solving tasks independently?					

Please give us your thoughts regarding problem solving:

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Riding at the Playground

John loves to ride a Big Wheel (because they are made with 3 tires.

He likes to go to the playground because there is a place just for Big Wheel riders and bicycle riders to use.

When he got to the playground he joined 2 other Big Wheel riders and 3 bicycle riders.

How many wheels were on the playground?

Appendix C
Grades 3-5 Pretest

Too Much Food

Mrs. Green's Class had too much delicious food for their class party because many parents sent in treats. The class decided to invite the other third graders to their party. 30 students ate pizza. 25 students ate hot dogs. 15 students ate both pizza and hot dogs. How many students ate all of this delicious food?

Appendix D
Scoring Rubric

Math Problem Solving Rubric

SCALE	4	3	2	1
SHOWS EVIDENCE THAT PROBLEM WAS UNDERSTOOD	Shows rigorous understanding of the problem	Shows substantial understanding of the problem	Shows limited understanding of the problem	Shows little or no understanding of the problem
USES INFORMATION APPROPRIATELY	Explains why certain information is essential to the solution	Uses all appropriate information correctly	Uses some appropriate information correctly	Uses inappropriate information
APPLIES APPROPRIATE PROCEDURES	Explains why procedures are appropriate for the problem	Applies completely appropriate procedures	Applies some appropriate procedures	Applies inappropriate procedures
USES REPRESENTA-TIONS CHARTS/GRAPHS PICTURES, ECT.	Uses a representation that is unusual in its aesthetic value or math precision	Uses a representation that clearly depicts the problem	Uses a representation that gives some important information about the problem	Uses a representation that gives little or no significant information about the problem
SHOW COMPETENT USE OF MATH	Makes a general rule about the solution that can be applied to another problem	Shows complete competence in using math	Show some competence in using math skips some important steps or leaves out important info.	Shows incompetent use of math

NAME _____ SCORE _____

20-18 = A 17-14 = B 13-10 = C 9-7 = D 6-0 = F

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Appendix E
Problem Solving Strategies

1. CHOOSE AN OPERATION

2. WORK BACKWARDS

3. DRAW A PICTURE

4. LOOK FOR A PATTERN

5. GUESS AND CHECK

6. USING DATA FROM A CHART

Appendix F
Writing Stems

Dependent Variable: Second, fourth, and fifth grade students showing improvement in math problem solving strategies.

Weekly Math Journals

Once every week, each student will be asked to write in his or her math journal. The students will be asked to choose one of four stems to complete in about a 15-minute session. The stems are:

One problem-solving strategy I learned this week was _____, and this is how it could be used.

One problem-solving strategy I used this week was _____, and this is how it was used.

One problem-solving strategy I could have used this week was _____, and this is how it could have been used.

One problem-solving strategy I still don't understand is _____, and this is why I'm confused.

The journals will give the students an opportunity to reflect on their math problem solving strategies. The information written by the students will allow the teacher to document the frequency of use for specific strategies. Also, the students' reflections will assist the teacher in determining which problem solving strategies may need further instruction or review.

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Appendix G
Problem Solving Steps

PROBLEM SOLVING

THINK ABOUT IT

WHAT IS THE QUESTION OR PROBLEM?

CHOOSE A PLAN

EXAMINE YOUR CHOICES AND PICK A STRATEGY

CARRY OUT YOUR PLAN

WORK THROUGH THE PROBLEM CAREFULLY.

CHECK YOUR ANSWER

DOES THE SOLUTION WORK?

Appendix H
K-2 Posttest

Sweet Sale

Andrew loved to stop at the candy store once a week to buy himself a treat. There was a new sign above the candy counter. The sign said that when you buy your first piece of candy it will cost 5 cents, but each piece of candy after that would cost only three cents. Andrew thought this was an excellent time to spend the twenty cents in his pocket. How many pieces of candy did Andrew have after giving the clerk his 20 cents?

Appendix I
Grade 3-5 Posttest

Good-bye Party Fun

Brian's family was moving to a new town to be closer to his grandparents. All his friends organized a good-bye party for him with lots of games. Everyone liked the Block and Can game the most where they had to throw balls to knock down a large block on one table, and a small can on another table. The thrower got 15 points for every large block knocked down, and 30 points for every small can knocked down. Brian scored 210 points, which made him the thrower with the highest score. He won a camera and took lots of pictures of his friends so he would remember them well. What is the least amount of blocks and cans that Brian could have knocked down to reach 210 points?

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